Dielectric inserted as shown

\[ C \]

\[ \frac{\kappa}{d} \]

Equivalent

\[ \frac{\kappa}{d/2} \quad \frac{\kappa}{d/2} \]
Dielectric inserted as shown

Equivalent

$\frac{d}{2}$
Electric circuit needs battery or generator to produce current – these are called sources of emf.

Battery is a nearly constant voltage source, but does have a small internal resistance, which reduces the actual voltage from the ideal emf:

\[ V_{ab} = \varepsilon - Ir. \]
This resistance behaves as though it were in series with the emf.
Four point charges of varying magnitude and sign are arranged on the corners of the square of side d as shown in the figure. Which of the arrows shown represents the net force acting on the point charge with a charge +Q?

A) A  
B) B  
C) C  
D) D  
E) none of the above
A series connection has a single path from the battery, through each circuit element in turn, then back to the battery.
The current through each resistor is the same; the voltage depends on the resistance. The sum of the voltage drops across the resistors equals the battery voltage:

\[ V = V_1 + V_2 + V_3 = IR_1 + IR_2 + IR_3. \]
A point charge $q = +1 \, \mu\text{C}$ is located at the origin. What is the flux of the electric field of this charge through a square whose corners are $(x, y, z) = (1, 1, 1), (-1, 1, 1), (-1, 1, -1)$, and

A) $0$
B) $1.0 \times 10^4$ N m$^2$/C
C) $1.9 \times 10^4$ N m$^2$/C
D) $11.3 \times 10^4$ N m$^2$/C
E) $0.5 \times 10^4$ N m$^2$/C
From this we get the equivalent resistance (that single resistance that gives the same current in the circuit):\[ R_{eq} = R_1 + R_2 + R_3. \]
Resistors in Parallel

A parallel connection splits the current; **the voltage across each resistor is the same**.
Resistors in Parallel

The total current is the sum of the currents across each resistor:

\[
I = I_1 + I_2 + I_3'
\]

\[
\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}.
\]
Resistors in Parallel

This gives the reciprocal of the equivalent resistance:

\[
\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}. \quad \text{[parallel]}
\]
If an electric field of magnitude 25 V/m makes an angle of 30° with a path of length 10 m, then the integral of $E \cdot dl$ over this path has a value of

A) 125 V.
B) 250 V.
C) 217 V.
D) 30 V.
E) -250 V.
Two concentric conducting spheres of radii $a = 5 \text{ cm}$ and $b = 10 \text{ cm}$ have a potential difference $V = 1 \text{ V}$ between them. What is the charge carried by each sphere?

A) $1.1 \text{ nC}$
B) $10 \text{ nC}$
C) $2.2 \text{ nC}$
D) $5.5 \text{ nC}$
E) $100 \text{ nC}$
A carbon resistor has a resistance of 18 Ω at a temperature of 20°C. What is its resistance at a temperature of 120°C? (The temperature coefficient of resistivity for carbon is $-5.0 \times 10^{-4} \, \text{°C}$.)

A) 14 Ω  
B) 16 Ω  
C) 18 Ω  
D) 17 Ω  
E) 15 Ω